Mediating Factors of Statistics Anxiety in University Students: A Systematic Review and Meta-Analysis

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Abstract

Statistics play a key role in many areas of modern society including technology, social and behaviour studies, economics and the sciences. Statistics anxiety (SA) has a detrimental impact on academic experiences in university populations. Although, the mediator factors remain underexplored. We conducted the first systematic review and meta-analysis focused on SA in university students in the context of: statistical performance; individual differences in statistical learning; self-perceptions regarding statistics course and instructor; and sociodemographic factors. Searches were carried out in the databases: PsycINFO, PubMed, Scielo, and Web of Science, according to our pre-registration. Forty studies were selected for systematic review. Seventeen were included in a series of six meta-analyses concerning: academic achievement, attitudes, self-perception, procrastination, and gender. Findings reveal learning strategies, procrastination, self-efficacy and self-awareness as predictors of SA. However, the impact of sociodemographic data in these moderators is still uncharted. We concluded with a critical appreciation of the selected studies and presented future directions for research in SA.

Keywords: statistics anxiety; mathematics anxiety; university students; statistics learning; meta-analysis.

Introduction

The Statistical Society of Canada state that statistical practises play a vast and ever expanding role in many areas of modern society including technology, health and social studies, economics and the sciences.¹ In the last decade, statistical knowledge has been established as an important tool in interdisciplinary academic education, which is why statistics courses are employed in various areas of third-level training.^{2,3} Despite an abundance of statistical information in daily societal practises (e.g., election polls), such topics are still considered complex, uninteresting, and lacking in application by many students.⁴ In Human and Social Sciences courses in particular, a greater tendency exists among students to present with difficulties understanding statistical content, in comparison to science, technology, engineering and mathematics (STEM) areas. Such reported difficulties only bolster the negative beliefs and emotional symptoms relating to statistical learning.⁵⁻⁸ Statistics anxiety (SA) was characterized by Zeidner as excessive worry, intrusive thoughts or tension occurring when one is exposed to statistical content.⁹ Onwuegbuzie and Wilson advanced this further, defining SA as a negative emotional state encompassing by behavioural and cognitive symptoms which commence when the individual is faced with environments, tasks, or evaluations related to statistics.⁵

Onwuegbuzie and Wilson originally classified the possible predictive variables of SA as situational, dispositional, and environmental. Situational variables relate to the particular stimulus object or statistical event (e.g. teaching method), dispositional variables comprise the student's individual and personal characteristics, while environmental variables speak to student's demographic background (e.g. sex, age, race, ethnic group).⁵ Subsequently, Cui and colleagues suggested an update of this classification, dividing the dispositional variable into the following subcategories: 1) Individual attitudes, motivation, and experience related to statistics; 2)

Individual behavioural traits (e.g. procrastination, learning strategies); 3) Individual characteristics, which now include environmental factors as well as the addition of a further 'cognitive variable'. These same authors acknowledge the need for more longitudinal and experimental studies to identify exact causes of SA.² This systematic review and meta-analysis utilises the above model in an attempt to better understand the relationship between individual differences (attitudes, behavioural, self-efficacy, perfectionism) and SA.

Similar to statistics, mathematics is integral to the undergraduate and graduate curriculum for several courses in STEM and Social Sciences. Students often report experiencing math anxiety (MA), or a negative emotional response to situations involving the manipulation or application of mathematical knowledge.⁵ Therefore, both concepts can warrant confusion among students and researchers, which is why it is important to make the distinction between SA from MA.

Indeed, it has been suggested that MA and SA could belong to a single construct: They were both initially classified as state anxiety stemming from a content-oriented situation, and share emotional elements.¹⁰ Furthermore, Baloğlu states that both constructs share similar antecedents (dispositional, situational and environmental).¹⁰ MA and SA scales are also moderately and positively correlated according to Zeidner ($r = .41, p < .001$) and Birenbaum and Eylath ($r = .54, p < 0.001$), and relate to factors such as numerical ability.^{9,11}

However, many researchers hypothesise that MA and SA are still, in actuality, separate constructs. Both Baloğlu and Cruise and colleagues pointed out that the main difference concerns the cognitive processes involved in each.^{10,12} For example, performance in statistics depends on cognition relating more closely to verbal reasoning, requiring greater manipulation of mathematical concepts. While MA contributes significantly to the development of SA, they are generally not regarded as one and the same construct.

While both have unique components and exert different effects on performance.^{6-8,13,14,15,16}

In light of this divergence, some researchers advocate a close relationship between the constructs, suggesting that if MA affects academic performance throughout the school years, independent of mathematics ability,¹² SA in higher education could be an after-effect.^{15,16} Further to this, Eshet and colleagues found the relationship between previous mathematics achievement and academic dishonesty to be mediated by SA, raising the importance of associating both constructs in research while further exploring the specific impacts of SA.¹⁷

Statistics Anxiety Measures

According to Baloğlu and Zelhart, there are two groups of instruments used to measure SA: 1) Tests developed from math anxiety scales, such as *Statistics Anxiety Scale (SAS)* and *Statistics Anxiety Inventory (SAI)*; 2) Tests developed exclusively to measure SA, such as *Statistical Anxiety Rating Scale (STARS)*.^{5,6,18-20} Nowadays, STARS is perhaps the most widely used measure of SA comprised of six subscales: Interpretation Anxiety, Test and Class Anxiety, Fear of Asking for Help, Worth of Statistics, Computation Self-Concept, and Fear of Statistics Teachers.

Chew and colleagues' investigation of the internal consistency and structure of the STARS in both Singaporean and Australian psychology students indicated that the six factors comprising the STARS are underpinned by two superordinate factors: statistics anxiety and attitudes toward statistics, rather SA only. Although this result was not generalised to other undergraduate samples, authors suggested using one part of STARS to assess SA and the other to assess attitudes toward statistics.²¹ Thus, attitudes toward statistics may be considered a multidimensional construct composed of: a) Affect (feelings towards statistics); b) Cognitive Competence (attitudes on capacity for statistics); c) Value (attitudes on the relevance of statistics) and d) Difficulty (attitudes regarding complexity of the problem).^{22,23} This discourse is

important to consider in the comparison and assessment of studies implementing the STARS.

Purpose of the Present Study

To our knowledge, there are to date, no systematic reviews or meta-analyses pertaining to SA in university students, only theoretical literature reviews. Thus, this study is justified as an updated methodological contribution to the critical analysis of SA, as a means of deepening the theoretical discussion and clarifying the interplay between predictor variables and performance in statistics.

We aim to assess variables relevant to the university student which might mediate SA. The following research questions will be explored: 1) Does the presence of SA mediate university student's statistics academic performance?; 2) How do individual differences (i.e. procrastination, attitudes, negative affect, perceived self-efficacy) contribute to the experience of SA?; 3) Is SA mediated by students' self-perceptions in statistics contexts?; 4) Do gender and ethnicity influence SA in university students? Meta-analyses were carried out to further investigate more specific mediators of SA in student populations which were brought to light over the course of the systematic review: specific attitudes towards statistics, academic achievement, negative affect, self-efficacy and gender. It is expected that the analysis of these questions will enhance understanding of the determinants of SA throughout third level education. This in turn, will contribute to the development of interventions to improve the delivery of course content and material, or approaches to teaching and studying statistics at university level.

Method

The study was conducted following the parameters detailed in the pre-registration on OSF (<https://osf.io/qsfvvr/>) and based on the recommendations of the Preferred Reporting Items

for Systematic Reviews and Meta-Analyses (PRISMA) model

(<http://prisma-statement.org/>). To do that, the following steps were performed: identification of the aim of the review, definition of the databases and the inclusion and exclusion criteria, critical analyses of selected studies and data interpretation.

Identification of relevant papers

The first search was made on April 6, 2020, and the last on May 25, 2021, using the following databases: PsycINFO, PubMed, Scielo, and Web of Science. Both searches were made using the following terms and with necessary adaptations to Boolean operators: *math anxiety* OR *mathematics anxiety* OR *mathematical anxiety*; “*statistics anxiety*” OR “*statistical anxiety*”; “*college student* OR *academic student* OR *university student* OR *graduate student* OR *undergraduate student*”. Due to the close relationship between MA and SA established in the literature, articles regarding SA in which MA was also assessed were included in the search. The terms were used only in English.

Eligibility criteria

This systematic review included both qualitative and quantitative research, without time restriction. AT and LR screened scientific papers including the following terms as selection criteria: statistics anxiety. Participants were undergraduate or postgraduate students, of all genders, and without restriction pertaining to age or academic area. SL and JR selected studies included in the meta-analysis and JR performed the meta-analysis.

Exclusion criteria

Following extraction of duplicate papers, articles were excluded if: (1) the focus did not take into

consideration SA; (2) the paper was written in a language other than English, Spanish, or Portuguese; (3) the paper was a literature review; (4) the sample did not correspond to the selected population (undergraduate and postgraduate university students); (5) texts in other formats such as dissertations, thesis, chapter, or editorials; (6) incomplete texts; (7) research implementing psychological interventions; (8) papers restricted to measuring psychometric properties of scales only; (9) studies investigating mathematics anxiety only.

All abstracts were screened by LR and AT. Following initial exclusion (1 to 5), all remaining texts were read in full and remaining exclusions (6 to 9) were made after LR and AT's weighting. In the event of an impasse, the senior author FS was consulted. A Kappa index of agreement equal 0,853 between the examinations of LR and AT was obtained, considered excellent according to Landis and Koch.²⁴

It is important to mention that the paper of McGrath and colleagues is divided into two studies and that only the second, meeting inclusion criteria, was analysed in this systematic review, while the first is an intervention.²⁵

Quality Assessment Criteria

Quality assessment was performed to give an overview of the methodological rigor of the analysed papers and was carried out by two reviewers (LR and AT). Two standardised checklists were used to account for longitudinal, cross-sectional and qualitative studies. To analyse quantitative research (n = 37), the Newcastle-Ottawa Quality Assessment Scale was implemented, adapted for cross-sectional studies.²⁶ Since all papers included were cross-sectional and used a convenience sample, the section "Assessment of the outcome" was not appropriate and so, was not incorporated. The scale showed a total score of six, distributed as follows: "Selection" (maximum 3 points), "Comparability" (maximum 2 points), and "Outcome"

(maximum 1 point). Studies with scores of 5-6 were considered high quality; scores of 3-4 medium quality and scores of 0-2 were low quality.

Hawker and colleagues' tool was used for qualitative studies ($n = 3$). This tool evaluates nine categories through four levels: a) good (4 points); b) fair (3 points); c) poor (2 points); and d) very poor (1 point).^{27,28} The scores for each category are summed and the total result is interpreted as follows: high quality: 30-36 points; medium quality: 24-29 points, and low quality: 9-23 points. Since the studies included for the meta-analysis derive directly from the systematic review, the same quality assessment was used.

Results

Full search results are better detailed in Figure 1. The first screening yielded a total of 234 papers, with 35 excluded as duplicates. The remaining 199 papers were analysed for title and abstract, with 87 being selected, and read in full. 40 papers were selected for qualitative synthesis.

The most frequently appearing scientific journals found in this review were: *Personality and Individual Differences* and *Learning and Individual differences*. The most common evaluation tools were the *Statistics Anxiety Rating Scale* (STARS; see Ref.19), and *Statistical Anxiety Scale* (SAS; see Ref. 20). Results are organised to display descriptive findings first, and results from each category of analysis subsequently.

Figure 1

Diagram according to the PRISMA protocol systematic review guidelines.

Quality Assessment

Twenty-five papers were rated as medium quality (81%), while five studies were classified as high quality (16%), according to criteria of the Newcastle-Ottawa Quality Assessment Scale and the Hawker and colleagues tool for qualitative studies.^{25,26} From the 17 studies included in the meta-analysis, 1 was rated as low quality (5%), 14 were rated as medium quality (85%) and 2 were rated as high quality (10 %). The scores obtained for each article are shown in Tables 1-4 below. One further paper was excluded during the quality assessment with a score of 2 (See Table 2).

Most of the studies exhibited limitations surrounding sample selection and representation, with a lack of information about sample size and random sequence, using just a single sample for the research. These limitations may equate to problems when generalizing the results.

Descriptive findings

Scimago Journal & Country Rank (<http://www.scimagojr.com/>) was used to verify the quality of the chosen journals and classify them into quartiles. From the papers analysed, 19 fell in Quartile 1, 11 in Quartile 2, 2 in Quartile 3, and 5 papers in Quartile 4. One journal was evaluated only in 1999, and 3 papers were not found in the Scimago rank (Tables 1-4).

The first study included in this review was published in 1991 and the last in 2021, with an average of 2 papers per year, and 11 articles (27,5%) published in the last 5 years. Sample size varied from 6 to 1112 participants (mean = 272, SD = 256), and a percentage of studies employed a cross-sectional methodology. The studies were conducted across 14 countries, with the majority coming from the United States (n = 17), followed by the United Kingdom (n = 5), Spain (n = 3), Israel (n = 2), Austria (n = 1), Columbia (n = 1), Canada (n = 1), Indonesian (n = 1), Iran (n = 1), Ireland (n = 1), South Africa (n = 1) and Turkey (n = 1). Five studies had data simultaneously collected in

two countries: Austria and Georgia (n = 1); Austria and the United Kingdom (n = 1), Italy and Spain (n = 2), and Turkey and the United States (n = 1).

In total, 10,892 people participated in the studies, with a significant majority of female (67%) over male (31%) participants, and the average participant age was 22.39 years (SD = 2.02). These gender differences could be due to most studies being conducted with students in the Human Sciences, in which there are predominantly female students. In fact, one study was conducted with female participants only while two studies did not report participant gender.^{29,30} Students' academic areas were: Human Science (80%), Health Science (15%) or STEM (15%). A percentage of the student's academic areas remain unspecified (13%) and it should be noted that some of the studies were carried out with students enrolled in multiple academic areas. Finally, some studies did not provide mean and/or standard deviation for age (See Tables 1 - 4).

Studies not included in Meta-analysis

Twenty-three studies included in the systematic review were not included in any of the meta-analyses performed. Those with the following criteria were not included: a) studies in which none of the measures complied with the categories identified for meta-analysis; b) studies using qualitative analysis only; c) studies with insufficient availability of data to perform the analysis. In such cases, attempts were made to obtain this data from relevant authors.

Analysis of Factors Affecting SA

Based on the findings of the searches carried out, and to meet the objectives of this systematic review, the articles were organized into 4 categories: 1) Statistics anxiety and academic factors; 2) Statistics anxiety and individual differences; 3) Statistics anxiety and self-perceptions; 4) Statistics anxiety and sociodemographic factors. Results for each category are

summarised, as shown in Tables 1-4.

Academic Factors

Table 1 displays the relationships evidenced between SA and academic factors yielding varying outcomes. For instance, while Paechter and colleagues found SA led to a direct negative effect on statistical performance, a small, direct positive relationship was found in the study of Macher and colleagues, while in Hoegler and Nelson's findings, SA had an indirect impact on academic performance.^{15,31,32} In other studies, no significant correlations between SA and performance were uncovered. However, it was found that statistics-related psychological flexibility, attitude and previous math experiences could act to mediate performance in statistics.^{33,34-36} Similarly, Zimmerman and Austin noted that the STARS Worth of Statistics, and Self-Concept subscales positively predicted final grades.³⁷

Only three studies investigated the effects of SA on specific cognitive abilities: probabilistic reasoning, statistics reasoning and reading comprehension/vocabulary.³⁸⁻⁴⁰ Results revealed that SA is impacted in a negative and significant way, by probabilistic reasoning (verbal–numerical and graphical–pictorial format). Reading comprehension, and reading vocabulary predicted SA in Black American graduates. However, Yusuf and colleagues did not find a relationship between SA and statistical reasoning.³⁸⁻⁴⁰

Regarding course modality (online or traditional), results were conflicted among studies. While Zimmerman and Johnson did not find differences in anxiety levels among students who either completed or did not complete their online statistics course, other studies did report differences between STARS subscales: in Frey-Clark and colleagues study, students who participated in statistical courses in an online modality reported higher SA in the Asking for Help subscale than students of traditional courses.^{41,42} Conversely, Zimmerman and Austin obtained lower scores in

online courses for the Asking for Help, and higher scores for the Worth of Statistics subscales, compared with face-to face courses.³⁷ Eshet and colleagues found a negative effect of student achievement on SA, in Planned Online Environment (POE), and Face-to-Face (F2F), but not in Covid-19-Emergency Remote Teaching (ERT).¹⁷ Thus, other variables might be considered predictors of success in the course completion, such as scores on the 'Goal and Outcomes Associated with Learning in Statistics' instrument (GOALS), and good grades in the first semester of the course.⁴¹

Table 1 *Statistic Anxiety and Academic Factors*

Individual Differences

In Table 2, eleven articles which approached existent relationships between SA and individual differences were included. Insights from the analysis process offer insights on emotional elements of statistics performance, in the context of behaviour, affect and personality.⁴³

Results on the role of this factor in SA indicate that students with lower rates of positive affect regarding statistics tended to present with higher levels of anxiety.⁴⁴ Also, SA correlated in a positive way with pathological traits of worry, intolerance of uncertainty, and coping strategy, while worry, perfectionism, and procrastination were yielded as specific predictors of SA.^{15,32,45-49} Furthermore, psychological flexibility, and academic dishonesty also mediated the relationship between SA and statistics achievement.^{18,36}

SA and learning strategies were investigated in three articles. The research of Kesici and colleagues and Vahedi and colleagues found a negative correlation between anxiety and the use of specific learning strategies, indicating that students who generally employ strategies for

learning statistical content more frequently reported lower levels of SA.^{45,50} On the other hand, Macher and colleagues obtained a significant, positive but weak relationship between SA and deep-level learning strategies, in which the highest level of SA would indicate a need for increased application of a learning strategy.³²

Furthermore, both Macher and colleagues and Sesé and colleagues investigated possible relationships between SA and attitudes towards statistics.^{32,35} All three studies found a negative association between variables, whereby students who had more positive statistics attitudes demonstrated lower levels of SA. Only González and colleagues investigated academic engagement and motivation, comparing STEM and social science students. They found a negative correlation with SA, which suggests a need for further studies investigating how a sense of motivation might mediate SA.³

Table 2 *Statistic Anxiety and Individual Factors*

Self-perception Factors

Table 3 includes studies comparing SA with self-perception measures in university students. In all studies, relationships were found between SA and self-efficacy, or indeed, student's perceptions of their capabilities in statistics.^{9, 31, 51-53} In the research of Cendales and colleagues, higher scores in self-concept, self-perception and attitudes were related to increased SA levels, particularly in women, in both the STEM and Human Sciences areas.⁵¹ Furthermore, Onwuegbuzie's research pointed out significant negative correlations among the 6 factors of STARS and the self-perception scale (SPPCS), suggesting that students with low level creativity, intellectual ability, or perceived school competence tend to have higher SA levels.⁵³ It could be inferred from such findings that the more confidence a student has in their own ability, the less likely they would be to suffer the effects of SA.

Also, three studies aimed to identify students' perceptions of factors relating to anxiety levels, using qualitative methods.^{25,29,54} Factors perceived as propellants in the development of SA included: fear of mathematics (math phobia); lack of connection of content to daily life; fear of making a mistake; inability to decode terminology and statistical symbols; worry, frustration and feelings of incompetence.^{29,54}

Regarding possible remediation of SA, students suggested the following: 1) instructors' personality characteristics; 2) teaching methods with more practical applications; 3) more qualitative evaluations; 4) clarity of the instructor's expectations (See Ref.25); 5) tests with more multiple-choice questions and space to solve problems; 6) access to formulae during evaluation, and 7) visual tips and learning materials.²⁹

Table 3 *Statistic Anxiety and Self-Perceptions*

Sociodemographic factors

Table 4 encompasses an analysis of sociodemographic variables. Most of the studies examined SA and participant gender and found conflicted results. In Ralston's research, women presented a higher probability of reporting SA.⁵² Baloglu and colleagues reported higher levels of SA among women, but only on the Interpretation Anxiety and Test/class Anxiety subscales of the STARS.⁵⁵ Similarly, Cendales and colleagues concluded that women, studying Human Sciences, with lower levels of self-concept, self-efficacy, and attitudes, showed higher levels of anxiety. Curiously, they found female participants with larger reserves of those traits also had high levels of SA, in both Human Sciences and STEM academic areas, which the authors suggest may be attributable to stereotypes surrounding gender and ability for mathematics and statistics.⁵¹ Ralston and colleagues findings diverged in the sense that male mature students were most likely to report SA.⁵⁶ Alternatively, some studies did not find any gender differences regarding

SA.⁵⁷⁻⁵⁹

Most of the studies found differences related to ethnicity and SA. Black American students generally had higher levels of anxiety than Caucasian Americans, and American students reported higher levels of SA on four of the six STARS subscales than Turkish students (Worth of Statistics, Interpretation Anxiety, Fear of asking for help and Fear of statistics instructor).^{55,60} Italian students scored higher on Test anxiety and Fear of asking for help subscales than their Spanish counterparts while, no differences were found between Caucasians and Latino/Hispanic groups.^{39,57} It should be noted that in some of these studies, women made up the majority of the sample.^{57,60}

Other variables less investigated in the accumulated studies were age, academic area, and parents' education level. Both Baloğlu and Ralston's studies found that older students were likely to experience more anxiety, while the studies of Mji and Gonzalez and colleagues reported differences in anxiety in students' area of study, whereby students of the humanities experienced more SA than their counterparts enrolled in science courses.^{3,10,52,58,59} Ralston also identified that the educational level of parents did not affect the level of statistical anxiety.⁵² Largely divergent results tell us a there is a stark need for further to understand environmental and demographic differences in SA.

Table 4 *Statistic Anxiety and Sociodemographic Factors*

Results from Meta-analyses

Several of the included studies contained sufficient information for conducting quantitative analyses on the relationship between SA and attitudes towards statistics, academic achievement, negative affect, self-efficacy, procrastination (see supplementary materials for a

list of instruments used for their assessment), and gender. Thus, separate meta-analyses were performed to further explore these relationships and clarify the somehow ambiguous results found in some of the qualitative analyses.

In relation to the data extracted, the assessment of attitudes towards statistics included five studies investigating positive attitudes (e.g., interest in statistics, importance of statistics) and two studies investigating negative attitudes (i.e., negative problem orientation and task aversiveness). This leads to both positive and negative correlations indicating broadly similar results (e.g., negative correlations between anxiety and positive attitudes and positive correlations between anxiety and negative attitudes). For this reason, the positive correlation coefficients were converted into negative values, multiplying the score by -1, before conducting the analysis allowing all scores to be in the same direction. Instruments used for measuring SA include the Statistical Anxiety Rating Scale (STARS), the Statistical Anxiety Scale, the Statistics Anxiety Inventory, and the Statistical Anxiety Measure.^{9,20,34,45} However, the STARS was the most used, being employed in 21 studies.

The STARS includes six subscales: Fear of Asking Help, Interpretation Anxiety, Test and Class Anxiety which evaluate statistical anxiety, and Computational Self-Concept, Worth of Statistics, and Fear of Statistics Teachers which assess attitudes towards statistics.²⁰ We found important differences in both the use of the scale and how its results were reported, since studies could report the sub-scales individually or calculate a total score from different sub-scales. Authors were contacted for the correlation score of each subscale with the other outcome variables as an attempt to have a homogeneous data set. However, in many cases information could not be provided. For this reason, in studies where only subscales' correlations were reported and not the total score of the scale, these were converted into Fisher's Z and a mean score was calculated and used for analyses. Thus, all analyses were conducted using a

single statistical anxiety score. In the case of gender, where the reported scores were not correlation coefficients but means and standard deviations, a similar procedure was used to obtain a single mean and standard deviation of anxiety for each gender. The Standardised Mean Difference between male and female participants was calculated to conduct the meta-analysis, with positive values indicating higher SA in women and negative values indicating higher SA in men.

All analyses were performed in R (R Core Team, 2021) with the 'metafor' package, using a random-effect model with the Restricted Maximum Likelihood method.⁶¹ Figure 2 summarises the results from all analyses. Although all forest plots are presented within a single figure, each analysis was done individually. Results from all variables, except for gender, are expressed in terms of correlation coefficients, where positive values indicate a positive correlation, and negative values indicate negative correlations.

Figure 2

Forest plots depicting the effects of the analysed variables on anxiety

As observed in Figure 2, most analyses showed a significant relationship between the investigated variables and anxiety, except for academic achievement. Furthermore, all relationships were in the expected directions and ranged between $Z = |0.22|$ and $|0.54|$ which can be regarded as moderate to large per the general guidelines provided by Cohen.⁶² In relation to heterogeneity tests, moderate heterogeneity was found between studies in the analysis of academic achievement ($Q = 27.446$, $df = 6$, $p < .001$; $I^2 = 72.41\%$; $\tau^2 = 0.0156$), and self-efficacy ($Q = 7.488$, $df = 3$, $p = 0.058$; $I^2 = 65.91\%$; $\tau^2 = 0.0194$). On the other hand, attitudes towards statistics ($Q = 7.043$, $df = 5$, $p = 0.2175$; $I^2 = 31.16\%$; $\tau^2 = 0.0023$), negative affect ($Q = 5.212$, $df = 5$, $p = 0.3916$; $I^2 =$

17.13%; $\tau^2 = 0.0019$), procrastination ($Q = 4.754$, $df = 4$, $p = 0.314$; $I^2 = 15.07\%$; $\tau^2 = 0.0011$), and gender ($Q = 7.764$, $df = 7$, $p = 0.354$; $I^2 = 6.29\%$; $\tau^2 = 0.0067$) presented a more homogenous sample of studies.

The heterogeneity found in the analysis of academic achievement was entirely produced by one specific study. On a sensitivity analysis, excluding the study by Sese and colleagues reduced heterogeneity to 0 as measured by I^2 ($Q = 4.339$, $df = 5$, $p = 0.502$; $\tau^2 = 0$) and the results remained non-significant ($Z = -0.01$, 95% CI = $[-0.08, 0.06]$, $p = 0.847$).³⁵ We did not find any specific characteristic in the study that could explain the heterogeneity it introduced, since samples between studies had similar characteristics (e.g., young adults, approximately 70% female, from developed countries), and measurement instruments and procedures were also similar (e.g. use of the same scales, similar outcome measure for academic achievement). It is possible that the difference in effect size is not due to true heterogeneity, but to a sampling error.

In the case of perceived self-efficacy, heterogeneity seems to be derived from the instruments used for its measurements. The study of Hoegler & Nelson, and McGrath and colleagues. performed a direct evaluation of perceived self-efficacy on statistics, while Onwuegbuzie, and Zeidner evaluated academic self-efficacy and mathematics self-efficacy, respectively.^{9,25,31,53}

It is worth mentioning that some authors consider MA as equivalent to SA. Since five of the included studies reported both MA and SA, we performed additional analyses on a combined score including both types of anxiety. Results are presented in detail in the Supplementary Materials.^{15,31,48} In general, these results barely present any difference with those obtained from considering only SA. In all cases, correlation scores are in the same direction, and of very similar effect size, which could suggest equivalence of these scales, at least in these specific samples.

Discussion

Statistics anxiety increases struggle in the life of the university student in terms of academic and professional performance, or of course, daily life activities. The present systematic review and meta-analyses is the first to methodologically investigate statistics anxiety in university students, and the potential predictor variables, particularly in the context of statistics performance, individual differences, self-perception, and sociodemographic factors. Studies that measured both mathematics anxiety and statistics anxiety were included. Findings are discussed in the context of our research questions.

Does SA impact statistical performance in university students?

The systematic review shows that academic performance in statistics does seem to be impacted by SA. The exact nature of this impact, however, is less clear. While many studies analysed reported relationships, both positive and negative, direct, or indirect; some reported no significant relationship between SA and statistics achievement.^{15,31-33,35,36} Further explorations in our meta-analysis reiterated this lack of significance. One explanation for the inconclusiveness, which has been addressed in previous studies, is that performance in statistics does not necessarily depend exclusively on SA, but also on cognitive and individual predictors such as previous math grades, procrastination, state anxiety, self-efficacy, statistics-related psychological flexibility, and attitudes.^{15,31,32, 35,63,64} Alternatively, variables including school year, academic area, type of class (online or traditional), or previous academic experiences may also play a role.^{7,17,37,41,42} Hamid and Sulaiman's study, theorised that math score was a predictor of performance in statistics, but not necessarily SA.⁶⁴ Thus, considering the small number of studies, and the variance in the results, further research should shape hypotheses around the impact of cognitive and individual variables over SA and statistics performance.

Finally, just three studies analysed the relationship between SA and cognitive ability.^{39,40}

Cruise and colleagues stated that statistics go beyond the manipulation of mathematical problems.¹⁴ As such, statistics cover data analysis, critique, extraction of moderation and mediation, as well as the ability to make decisions based on the data.⁶⁵ Consequently, it seems possible for the student to develop some level of SA when having to deal with more complex cognitive abilities, such as abstraction, interpretation, and problem resolution when performing in statistics. It may also be beneficial to examine the interplay among cognitive abilities (e.g. attention, language processing and executive function) and SA to determine their exact effect on statistical performance.

Do individual differences in statistics learning impact statistics anxiety manifestations?

Our analyses unveiled conflicting results regarding the impact the individual variable of learning strategy has on SA. Many of the studies concluded that students with the ability to self-regulate receive the most benefit from learning strategies, since they often set goals and objectives, monitor their own performance, schedule time for study, organise their learning environment (physical and social), and solicit help when necessary.⁶⁶⁻⁶⁸ We can hypothesise that if a student is more conscious of the methods and strategies which facilitate their learning in statistics, they will deal better with the feelings of anxiety which may accompany any difficulties that arise in their learning. A point that needs to be addressed is the multiple definitions, scope and ratings for learning strategies, which might explain, at least in part, the differences in the results.⁶⁸⁻⁷¹ Rodarte-Luna and Sherry highlighted that studies need to advance towards specific statistics strategies, which will help clarify the roles of particular strategies in the presentation of SA.⁷²

Findings from both the systematic review and the meta-analysis significantly linked SA with a student's tendency to procrastinate on statistical activities.^{15,32,45,49} Likewise, Walsh and Ugumba-Agwunobi found procrastination to be a predictor of SA (Subscales: Interpretation

Anxiety, Fear of Asking for Help, and Fear of the statistics instructor) in students of behavioural and social sciences.⁴⁹ In fact, several studies detail relationships between procrastination and other types of anxiety (test anxiety and state anxiety) also.^{73,74} In the context of these concurrent findings, it seems efforts to understand procrastination from individual viewpoints, as well as the consequences of SA on mental health (general anxiety, depression) may be of particular benefit to student populations and to the wider society.^{74,75}

Lastly, Mills found that many factors are determinants of students' attitudes toward statistics being either positive or negative, such as previous experiences with math or statistics, students' self-confidence, or teaching methods on the statistical course.⁷⁶ Correlational data from the meta-analysis supported the theorised bilateral relationship between the constructs; with positive attitudes toward statistics equating to lower levels of SA, and both negative attitudes and general negative affect acting as a predictor of SA.^{30,32,46,50} Unfortunately, due to the small number of studies evaluating negative or positive attitudes, these were combined into a single score for analysis and no specific conclusions regarding these two types of attitudes (negative and positive) could be drawn.

Although the research included in this study has identified individual mediators of SA, future studies might focus more on the specific educational strategies which work to alleviate SA and improve individual attitudes towards statistical learning (teacher behaviour, teaching method). Furthermore, it also seems necessary to verify interaction effects between demographic groups (e.g. gender, age, course, ethnicity), SA and individual differences.

Do self-perceptions regarding statistics course and instructor contribute to anxiety?

It seems that the way in which university students perceive their ability for statistics can indeed impact how SA is experienced, since self-perception, self-efficacy, and self-concept

tended to present an inverse relationship with SA in our analyses.^{9,31,52,53} Further insights from our meta-analysis attest to this trend, showing that across studies, the higher a student's reported assuredness in their capacity for statistics (self-efficacy), the lower their presentations of SA. This, perhaps, indicates a prospect for statistics instructors to employ teaching strategies and encourage learning behaviours which aim to increase self-efficacy among students to reduce SA.

Although relatively few studies to date have focused on students' self-perceptions regarding SA, factors currently reported as contributors in the literature indeed relate to methodological problems in teaching and assessment, professor behaviour, students' emotional aspects, and difficulty making calculations with statistical formulae.^{29, 54} Two studies observed that administering statistics tests without a time limit and/or with support material helped to significantly reduce SA. This data indicates the perceived importance of the learning environment may decrease SA levels.^{77,78}

Building on this, our analyses also suggest students' statistics instructors have an important role in the presentation of SA, through their relationship with their students. Hamid and Salaiman identified that psychology students present the highest anxiety levels in the STARS subscale detailing "Fear of the statistics instructor".⁶⁴ In Williams' research, SA was found to be influenced by the type of teaching instruction, whereby 'immediacy behaviours' displayed by the instructor significantly reduced presentations of SA in students.⁸⁰

The data presented here supports the importance of adapting methodologies in the statistics course as a means of reducing anxiety.^{64,78-80} According to Onwuegbuzie and colleagues, statistics courses should be taught so the focus is not on the statistics themselves, but the actual approach to the process of the data analysis, which would consequently reduce SA.⁸¹

Do gender and ethnicity influence SA?

In general, our results yielded a higher tendency among women to report SA.^{51,52,55} One study (see Ref.56) observed greater SA in men, while the others did not find differences between genders hinting at a lack of agreement within the literature, similar to the findings of Baloğlu and Zelhart's theoretical review.^{57-59, 17}

Some hypotheses can be drawn from these conflicting results. Since studies have been conducted in different countries (United States, South Africa, Columbia, and United Kingdom), contradictory results may be attributed to cultural differences; for example, the work of Guiso and colleagues report that countries with a more gender-equal culture display significant gender gaps in math scores.⁸² Another possible hypothesis is that perhaps gender can be a moderator of SA when in interaction with other situational variables, such as age or ethnicity.^{57,58} We tested for differences in the experience of SA between male and female participants through a meta-analysis, and our results supported the hypothesis that females indeed seem to experience higher levels of SA.

Some differences were observed in the literature on the relationship between SA and ethnicity, in which Black American and Caucasian American students were compared, but not Caucasian and Latino/Hispanic, whereby in both studies, women compose the majority of the sample.^{57,60} It could be theorised from this conflict, that statistics anxiety is an issue related more to socioeconomic factors, cultural and educational variables rather than genetic predisposition. Still, little previous research has been dedicated to the study of sociodemographic predictors of SA (income, ethnicity, age, area of study), inhibiting more in-depth conclusions on the data for now.

Limitations and Future Research

It should be noted that many studies investigated students of the humanities (mainly psychology), which problematizes the extrapolation of data from students in other schools of training such as STEM or business studies, who together, in addition to the 10% not identified, represent only 22% of all university students analysed. Future studies need to investigate and compare SA with other courses with the aim of understanding if there are differences among areas of study, which may help determine where remediation strategies are of most benefit. Furthermore, fewer MA studies were found than SA, which did not allow us to compare between both. Therefore, since it is suggested that SA could be an after-effect of MA, it is important that future studies investigate, simultaneously, MA and SA in university students, through longitudinal studies, if feasible.¹⁰

Another caveat is in the geographic regions where the studies were conducted. Alas, since this review aims to evaluate the literature on SA's situational and environmental background, cultural factors must also be considered. About 43% of the total sample comes from North America, 37% from Europe, and a few studies representing Asia, the MiddleEast, and Oceania. In general, the results were obtained from Western, Educated, Industrialised, Rich and Democratic (WEIRD) countries (See Ref. 83), meaning the number of works focused on populations outside the Euro-American axis is still small. The limited attempts to include diverse samples in many of the studies exemplify the need for improvements in this area, for instance, combining all Latino/Hispanic into a single category, or considering Asia as one whole unit.

Additionally, many of the studies qualified as medium quality, with limitations surrounding sample selection and size, even displaying crucial differences in their methodologies, which do not contribute to consolidating the data analysis, evidenced by the

high heterogeneity found in several of the meta-analyses. Thus, upcoming studies might aim to clarify such information to improve sampling design and power analysis and access samples more representative of the wider university population to allow for generalisation of findings.

Future systematic reviews and meta-analyses should also aim to analyse both experimental and quasi-experimental studies in order to obtain the most true-to-life insights on the causes of SA. One general methodological limitation which became apparent when preparing the meta-analyses is the lack of consistency in terms of how the STARS was utilised and its results reported. While some authors report total scores only, others report subscales or a portion of the subscales only, with very few reporting both subscales and total scores, making it difficult to adequately analyse or compare scores across studies and constructs. Further to this, it was challenging to gain access to the data needed to analyse each construct, as proper standard of data sharing is not yet a common practice in certain fields. While this is understandable in the cases of older studies, researchers might consider striving to ensure data remains secure and accessible (see Ref.84) allowing for replication and advancement on a topic as relevant as statistical anxiety. This lack of consistency and transparency in the reporting of data led us to calculate means between sets of correlation scores from the same study (after Fisher's Z transformation) despite the reported limitations of averaging correlation coefficients.⁸⁵ Researchers should also provide further descriptive and inferential information about their data to make it easier to perform future meta-analyses. Other avenues for future research on SA in university students can be drawn from the predictor variables discussed. One suggestion which was put forward by Rodarte-Luna and Sherry and was emphasised in the results of this review would be to investigate specific student learning strategies and how they affect SA.⁷² This may help account for the discrepancies in the relationship between learning strategies and SA in previous research as identified by this review. Another point which arose during the

investigation of self-perceptions was the need to review and develop pedagogical practises in statistics due to the impact of this factor on a student's emotional experience of statistics. Future research might conduct an in-depth exploration of the specific teaching methods that reduce presentations of SA, which could, eventually, be incorporated into an intervention study for students.

Conclusions

This systematic review and meta-analysis was the first to explore research on SA and how it pertains to the educational experience of university students. The findings have provided an incorporative and multidimensional insight into predictor variables of SA, working to understand relationships among statistics anxiety and performance, individual differences, self-perception, and sociodemographic variables in university students, which overall support the model of Chew and colleagues. Generally, the results of the studies incorporated in this review are at odds in their explanation of the consequences of SA on performance. Still, learning strategies, procrastination, self-efficacy, and self-perception present as significant predictors of SA. Finally, there is little clarity as to which sociodemographic data relate unequivocally to SA, due to the limited nature of research on this component. As discussed, the concurrences and conflicts identified within the literature provide knowledge on the limitations and future direction for research on SA. Thus, we conclude further studies on mediating factors are indeed necessary to provide clarity on the underpinnings of the construct, in the hopes of both preventing manifestations and improving the development of interventions targeting statistics anxiety in university students.

Disclosure Statement

The authors confirm there are no competing interests to report.

Authors contributions

Conceptualisation, methodology and data curation FS; data search LR and AT, quality assessment LR and AT; writing, editing and review AT, SL, JR and FS; meta-analyses JR. graphics and tables JR, AT. All authors revised the manuscript and approved the final version.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001 and the University College Dublin Ad Astra Studentship.

Data sharing (<https://osf.io/qsfvr/>)

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Table 1
Statistic Anxiety and Academic Factors

Author (year)	n	Age M (SD)	Evaluated academic area	Instrument used	Comparison	Main results	Quality score (Scimago Quartile)	Included in meta- analysis
Agus et al. (2016) ³⁹	Spain 127 Italian 1 376 Italian 2 173	Spain 20.32 (6.09) Italian 20.14 (4.29) Italian 2 19.69 (1.63)	Human science	SAS	Probabilistic reasoning	SA and probabilistic reasoning (-).	4* (1)	No
Collins, and Onwuegbuzie (2007) ⁴⁰	92	28.62 (7.40)	Unspecified	STARS	Reading vocabulary and reading comprehension.	Reading comprehension vocabulary predicted SA.	4* (2)	No
Eshet, Steinberger, & Grinautsky (2021) ¹⁷	291	22	Human science	STARS	Previous academic achievements, and learning environments (Covid-19- Emergency	SA and Student's achievements in online, and face- to-face environments (-).	5* (1)	No

						Remote Teaching, online, or face-to-face courses).				
Frey-Clark, Natesan and O'Bryant (2019) ⁴²	295	20.64 (5.37)	Human science	SAS	Students in online and traditional statistics courses	SA subscale: <i>Asking for Help</i> in online students > traditional students		6* (1)		No
Hanna and Dempster (2009) ³⁴	52	20.12 (4.79)	Human science	STARS	Predicted and Actual performance in Statistics.	SA impacted both predicted and actual performance.		3* (4)		Yes
Hoegler and Nelson (2018) ³¹	63	21.62 (3.89)	Human science	STARS	Prior GPA and final grades.	Self-efficacy (more than SA) predicted statistics performance		5* (Not available)		Yes
Lester (2016) ³³	93	22 (5.1)	Human science	STARS	Basic algebra test	SA and the grades obtained in the course (r = n.s.)		3* (2)		Yes
Macher et al. (2012) ³²	284	21.40 (3.76)	Human science	STARS	Final test of the statistics course.	SA and performance (+). SA and performance via state anxiety (-).		4*(2)		Yes

Paechter et al. (2017) ¹⁵	229	20.44 (2.89)	Human science	STARS RMARS	School years in math and grades in statistics.	Anxiety and performance (-).	4*(1)	Yes
Sandoz, Butcher, and Protti (2017) ³⁶	132	19.99 (2.89)	Human Science	SAS	Statistics test	SA performance and (r = o).	5* (2)	Yes
Sesé et al. (2015) ³⁵	472	22.54 (6.33)	Human science, and Health Science	SAS	Statistics test	SA performance and (r = o).	4*(2)	Yes
Yusuf, Suyitno, and Sukestiyarno (2019) ³⁸	33	19.76	STEM	SAM	Statistical reasoning	SA statistical reasoning (r = o)	3* (3)	No
Zimmerman and Johnson (2017) ⁴¹	353	Not available	Unspecified	STARS abbreviated	Time dedication in the course and grades.	SA performance and (r=o).	4* (1)	No
Zimmerman and Austin (2018) ³⁷	1112	Not available	Unspecified	STARS	Online and face-to-face courses. Final exam scores and successful course completion	SA subscales: Worth of Statistics and Self-Concept and final score (+). Course type impacted SA.	4*(1)	No

Note: SA: Statistics anxiety; SAM: Statistics Anxiety Measure; SAS: Statistical Anxiety Scale; STARS: Statistics Anxiety Rating Scale; STEM: Science, Technology, Engineering, and Mathematics. *Newcastle-Ottawa Quality Assessment Scale (adapted for cross-sectional studies); **Hawker et al. Scale.

Table 2
Statistic Anxiety and Individual Differences

Author (year)	n	Age Mean (SD)	Evaluated academic area	Instrument used	Comparison	Main results	Quality score(Sc imago Quartile)	Included in meta-analysis
Eshet, Steinberger, & Grinautsky (2021) ¹⁷	291	22	Human science	STARS	Academic Dishonesty	Achievement impacting Academic Dishonesty mediated by SA.	5* (1)	No
González et al. (2016) ³	STEM 468; Human Science 479	STEM 20.4 (2.6) Human Science 19.7 (1.7)	Human science, and STEM	Class-Related Emotion Scale	Motivation (learning strategies) and academic engagement	Perceived capability of statistics learning and SA (-) and use of learning strategies (+).	3*(1)	No
Jordan, McGladdery and Dyer (2014) ⁴⁸	99	23.11 (7.41)	Human science, and Health Science	STARS	General mental health among undergraduate students with dyslexia and without dyslexia	Worry, negation, return to religion, and positive reinterpretation predicted anxiety.	3* (2)	Yes

Justicia-Galiano et al. (2016) ³⁰	187	19.84 (4.47)	Human science	SAS	Inhibitory abilities and emotional intelligence (EI).	Anxiety and intrusive thoughts (+). Anxiety, EI and suppression of intrusive thoughts (-)	2* (2)	Yes
Kesici, Baloglu and Deniz (2011) ⁵⁰	320	21.28 (1.47)	Unspecified	STARS	Learning strategies	Learning strategies and computational anxiety levels (-).	4* (1)	No
Macher et al. (2012) ³²	147	20.8 (3.63)	Human science	STARS	Learning strategies, attitudes, and procrastination	SA and attitudes (-) SA and procrastination (+).	4*(2)	Yes
Macher et al. (2013) ⁸⁶	284	21.4 (3.76)	Human science	STARS	Attitudes and performance	SA and attitudes. (+)	4*(1)	Yes
Onwuegbuzie and Daley (1999) ⁸⁷	107	31.8(8.5)	Human science, and Health Science	STARS	Perfectionism	SA and Students' perfectionist behaviour (+)	4*(1)	No
Onwuegbuzie (2004) ⁸⁸	135	26(6.8)	Human science	STARS	Procrastination	SA and Self-perception scores (-)	4*(1)	Yes
Paechter et al. (2017) ¹⁵	225	20.44 (2.89)	Human science	STARS RMARS	Procrastination	SA and procrastination. (+)	4*(1)	Yes

Prentice, and Caska (2012) ⁴⁴	199	27.13 (8.07)	Human science	Questions about SA	Positive affection	SA and positive affect. (+)	5* (4)	No
Sandoz, Butcher, and Protti (2017) ³⁶	132	19.99 (2.89)	Human Science	SAS	Statistics-related psychological flexibility	Psychological flexibility moderates SA on performance.	5* (2)	Yes
Sesé et al. (2015) ³⁵	472	22.54 (6.33)	Human science, and Health Science	SAS	Attitudes	SA and attitudes (+)	4*(2)	Yes
Vahedi et al. (2012) ⁴⁵	246	23.15 (1.23)	Human science	SAM	Procrastination, and learning strategies	SA and procrastination (+). SA and learning strategies (-).	4* (4)	Yes
Walsh and Ugumba-Agwunobi (2002) ⁴⁹	93	23.3 (5.5)	Human science	STARS	Perfectionism, Procrastination, Trait anxiety.	Perfectionism and procrastination predict SA.	3* (1)	Yes
Williams (2013) ⁴⁶	97	31.47 (8.78)	Human science, and Health Science	STARS	Intolerance of uncertainty and worry	SA and Intolerance of uncertainty (+).	3*(2)	Yes

Williams (2015) ⁴⁷	103	31.37 (10.64)	Human science	STARS	Intolerance of uncertainty and worry.	SA and intolerance of uncertainty and worry (+).	3*(1)	Yes
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Note: SA: Statistics anxiety; SAM: Statistics Anxiety Measure; SAS: Statistical Anxiety Scale; STARS: Statistics Anxiety Rating Scale; STEM: Science, Technology, Engineering, and Mathematics. *Newcastle-Ottawa Quality Assessment Scale (adapted for cross-sectional studies); **Hawker et al. Scale.

Table 3
Statistic Anxiety and Self-Perceptions

Author (year)	n	Age Mean(SD)	Evaluate d academi c area	Instrument used	Comparison	Main results	Quality score(Sci mago Quartile)	Included in meta-analysis
Cendales, Vargas- Trujillo, Barbosa (2013) ⁵¹	332	19.8	Human science and STEM	SAS	Self-efficacy, self- concept and attitudes were compared to academic program and sex.	SA and self efficacy, self concept and attitudes in both Human science and STEM women. (-)	3*(4)	No
Hoegler and Nelson (2018) ³¹	63	21.62 (3.89)	Human science	STARS	Performance and Self-efficacy	SA and self-efficacy (-).	5* (Not available)	Yes
Malik (2015) ²⁹	6	23	Human science, and Health Science	SSAS	Factors that can act on SA levels.	Factors established: 1) Inability to decode terminology/symbols; 2) Feelings of Inadequacy; 3) Physiological	30** (3)	No

symptoms; 4) “Giving up” behavior.									
McGrath et al. (2015) - second study ²⁵	Study 2: 26	27.15 (3.85)	Human science	Interview	Factors that can reduce the SA and increase self-efficacy.	Factors established: 1) Instructor personality; 2) Teaching methods; 3) Assessment methods 4) Clarity of the instructor expectations.	27** (Not available)	No	
Onwuegbuzie (2000) ⁵³	146	31.5 (8.5)	Human science	STARS	Self-perceptions	SA and Self-perception scale (-).	4*(1)	Yes	
Pan and Tang (2005) ⁵⁴	7	33.86 (6.20)	Human science	Interview	Factors that act on SA	Factors established: 1) math phobia; 2) lack of connection of the content with daily life; 3) pace of class 4) teachers' behaviour.	29** (Not available)	No	
Ralston (2019) ⁵²	704	22 (5.3)	Human science	Own questionnaire	Epistemological legitimacy	SA impacts epistemological legitimacy and self-assessment of performance.	5* (1)	No	
Zeidner (1991) ⁹	431	27.85 (10.18)	Human science	SAI	Self-perception	Anxiety, self-perception and math ability (-)	4* (1)	Yes	

Note: SA: Statistics anxiety; SAI: Statistics Anxiety Inventory; SAS: Statistical Anxiety Scale; SASS: Students' Statistics Anxiety Scale; STARS: Statistic Anxiety Rating Scale; STEM: Science, Technology, Engineering, and Mathematics. *Newcastle-Ottawa Quality Assessment Scale (adapted for cross-sectional studies); **Hawker et al. Scale.

Table 4
Statistic Anxiety and Sociodemographic Factors

Author (year)	n	Age Mean (SD)	Evaluated academic area	Instrument used	Comparison	Main results	Quality score (Scimago Quartile)	Include d in meta-analysis
Agus et al (2019) ⁸⁹	Italy 290 Spain 130	Italy 19.68 (2.94) Spain 20.41 (6.17)	Human science	SAS	Ethnicity	SA subscales: Examination and Asking for Help in Italian students > Spanish students	4* (2)	No
Baloğlu (2003) ⁵⁸	246	27.15 (8.84)	Human science	STARS	Gender, age, and previous math experience (PME).	SA and student age (+) SA impacted by PME as a covariate.	4*(1)	No
Baloğlu, Deniz, and Kesici (2011) ⁵⁵	460	21.24 (1.47)	Human science,	STARS	Ethnicity, gender.	SA in American students > Turkish students. SA in women > men	4*(1)	No
Bui and Alfaro (2011) ⁵⁷	104	23.42 (6.76)	Unspecified	STARS	Gender, age, and ethnicity	There were no significant differences among the ethnic groups, and gender regarding SA.	3* (4)	No

Cendales, Vargas-Trujillo,Barbosa (2013) ⁵¹	332	19.8	Human science, and STEM	SAS	Academic area and gender.	SA in women related to self-concept, self-perception, attitudes,	3*(4)	No
González et al. (2016) ³	STEM 468 Human Science 479	STEM 20.4 (2.6) Human Science 19.7 (1.7)	Human and STEM	Class-Related Emotion Scale	Academic area	SA in STEM students < Human Sciences students	3*(1)	No
Mji (2009) ⁵⁹	226	Not available	Human and STEM	STARS	Gender and academic area	SA and gender, (r= n.s.)	4* (2)	No
Onwuegbuzie (1999) ⁶⁰	225	Caucasian:31.1 African American 35.6	Unspecified	STARS	Ethnicity	SA in Black Americans >Caucasian Americans	4* (2)	No
Ralston (2019) ⁵²	704	22 (5.3)	Human science, and others unspecified	Own questionnaire	Gender, age, math qualification, parents' level of education.	Women are more likely to report SA than men	5* (1)	No
Ralston et al (2020) ⁵⁶	732		Human science	Question about statistics anxiety (William et al., 2009)	Age, and gender.	Older males most likely to report SA.	4*(1)	No

Note: SA: Statistics anxiety; SAS: Statistical Anxiety Scale; STARS: Statistics Anxiety Rating Scale; STEM: Science, Technology, Engineering, and Mathematics.
*Newcastle-Ottawa Quality Assessment Scale (adapted for cross-sectional studies); **Hawker et al. Scale.